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EVALUATION OF LATERIZED EARTH MOIST CONCRETE IN CONSTRUCTION WORKS

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ABSTRACT

This paper evaluates the satisfaction of the minimum compressive strength requirement of laterized earth moist concrete for grade C20 of BS 8110 (1997) for use in reinforced concrete works, which is 20 N/mm2. Compressive strength test and water absorption tests were conducted with laterite partially replacing fine aggregate. Batching was by weight, mix ratio of 1:2:4 (cement: laterite/sand: granite) was used with a water/cement ratio of 0.3. $150\,mm$ *sized concrete cubes were cast and cured for 56 days, then weighed and crushed. The result shows that the compressive strength of the earth moist concrete (EMC) at 0%, 10% and 20% laterite replacement for 28days respectively are* $20.6N/mm^2$, $19.1\ N/mm^2$ *and* $18N/mm^2$. *The compressive strength of the EMC 0%, 10% and 20% laterite replacement for 56 days respectively are* $20.9N/mm^2$, $20.2\ N/mm^2$ *and* $19.1N/mm^2$. *These indicate that increase in the compressive strength of all the EMC specimen is directly proportional to the increase in curing age but increase in the laterite replacement reduces the strength.*

Keywords: Earth Moist Concrete, Laterite, Sand, Compressive Strength

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1. INTRODUCTION

Earth Moist Concrete products are in high quality demands in today's market with their usefulness to a large extent in the construction industry. Originating from rammed concrete, EMC gives a good immediate strength after its production and demoulding with sufficient density, high resistance to freezing and thawing, flawless appearance, dimensional accuracy and high resistance to abrasion. Earth-moist concrete three-component system (cement, aggregate and water) is gradually moving to a five-component system paving way for new possibilities for varying design of recipe [1]. Production of mass products like roof tiles, paving blocks, curbs etc are best done using zero-slump, dry or EMC. One major advantage of EMC is its workability properties which are as a result of its dry consistency allowing for immediate use after casting and mold vibration [2]. Earth Moist Concrete is one of the commonly used construction materials but there is a need to develop new and sustainable technologies to make concrete more affordable in a developing country like Nigeria. Establishment of good data base on concrete made from materials that are readily available like laterite in most developing countries can make concrete technology in these areas to be more affordable and economical [3,4]. Laterite naturally occurs widely in the tropics and subtropics. Laterites are common types of soils in Nigeria and are in abundance all over the country. They are used in foundation construction to fill and also a major material in highway construction, as well as a primary fine aggregate in the manufacture of the building blocks commonly referred to as "iatentic blocks" [5]. The mixture of fine aggregates, coarse aggregates, cement and water is called Concrete and chemical reaction between the cement and water forms a paste which hardens in a short time [6–8]. The cement-water paste binds the aggregates (sand and gravel or crushed stone) giving a rock-like solid. The grade of the paste and the aggregates determines the resulting construction material properties. Physical and Chemical properties like mechanical strength, chemical and volume stability with low permeability are developed by the concrete in the process of hydration and hardening.

Earth moist concrete is a concrete made for dry locations with low amount of water. It is also referred to as 'no slump concrete' or dry concrete, its plastic mixture makes it advantageous on sloping surfaces and where large masses are needed [1,9]. Due to the economic advantage of earth moist concrete, numerous earth moist concrete products are widely used in different parts of the world during construction works. To this end, earth moist concrete with characteristics of rapid hardening, high compressive strength and short processing time during production will be used to produce earth moist concrete products in short duration in order to speed up construction process and also meet high demands for them. Laterite is a weathered material composed principally of iron oxides, aluminum, titanium and manganese, and is classified as a soft porous earthy soil; often found 15 cm below the top soil [10]. In 1807, Buchanan in India gave the soil name "laterite" originating from a latin word "later" meaning brick [11]. Laterite is a major material in the embankments of roads and earth dam constructions [10,12]. Numerous researchers have worked on laterized concrete with the interest of having cheaper concrete [3,4,10,13–17]. Laterite has been passed suitable for use in the construction industry owing to recommendations from researches that have looked into different laterized concrete properties at different stages [18–24]. This research looks into the possibility of producing a laterized Earth moist Concrete, with the view of determining the compressive strength of Earth Moist Concrete using laterite as partial replacement for sand (fine aggregate). It also compares the durability of the earth moist concrete, and earth moist concrete (with laterite as partial replacement to sand) mix.

2. MATERIALS AND METHODS

The constituent material for the concrete was weighed adopting the mix ratio 1:2:4. Laterite was used to replace sand in ratios of 10 starting with 0% laterite: 100% sand; 10% laterite: 90% sand and 20% laterite: 80% sand [25]. The lateritic soil was sieved to exclude the clay content as well as the coarse aggregate contents of lateritic soils. The range of size used was $0.3mm$-$4.75mm$. The size ranges of coarse aggregates were chosen in compliance with BS 1881(1983)[26] which specifies that the maximum size of coarse aggregate should not exceed one-third of the smaller dimension of the concrete member. For this study, the maximum size used was 14 mm and is less than one-third of$100mm$, the smallest dimension of the test specimen. The materials were then mixed thoroughly by an electric mixer before adding the prescribed quantity of water and then mixed further to produce fresh Earth Moist Concrete. Water/Cement ratio of 0.3 was adopted.

The fresh Earth Moist Concrete was then filled into 45 concrete cube molds of dimension $150mm \times 150mm \times 150mm$ in approximately $50mm$ layers with each layer vibrated with a vibrator. The top of the molds were leveled and the samples were stored under damp sacking for 24hours outside the laboratory before de-molding. After de-molding, the 45 cubes were stored in the curing tank in accordance with BS EN 12390-2 [27] for the required curing age. The curing method that was adopted in this research was wholly water-submerged as it has been adjudged to be the best method for laterized concrete.

(a) 

(b) 

Figure 1 (a) Vibrated EMC in the mould (b) Demoulded EMC

2.2. Compressive Strength Test

The compressive strength test was carried out by using ELE 2000kN compression testing machine conforming to BS EN 12390 Part 3, 4 & 6 [27–29].

Figure 2 Loading arrangement for compressive strength test.

3. RESULT AND DISCUSSION

3.1. Water Absorption Test

Water absorption test was carried out on the samples to determine the rate at which the earth moist concrete retain/absorb water. The test specimen which had a dimension of $50mm \times 50mm \times 12mm$ was soaked in water (at room temperature) for moisture uptake for 2 hours and 24 hours. Water absorption was determined as the percentage increase in weight of the particleboard over the original or initial weight: $\text{WA} = \frac{W2-W1}{W1} \times 100$

Where: $WA = water\ absorption$ (%), $W_1 = initial\ weight$, $W_2 = final\ weight.$

Table 1 Water Absorption Test Average values

Curing Age	Water Absorption (%)		
	0% Laterite Replacement	0% Laterite Replacement	20% Laterite Replacement
7 days	2.41%	3.07%	3.60%
14days	2.70%	3.28%	3.77%
21days	3.30%	3.65%	4.17%
28days	3.40%	3.77%	4.40%
56days	3.80%	4.30%	4.80%

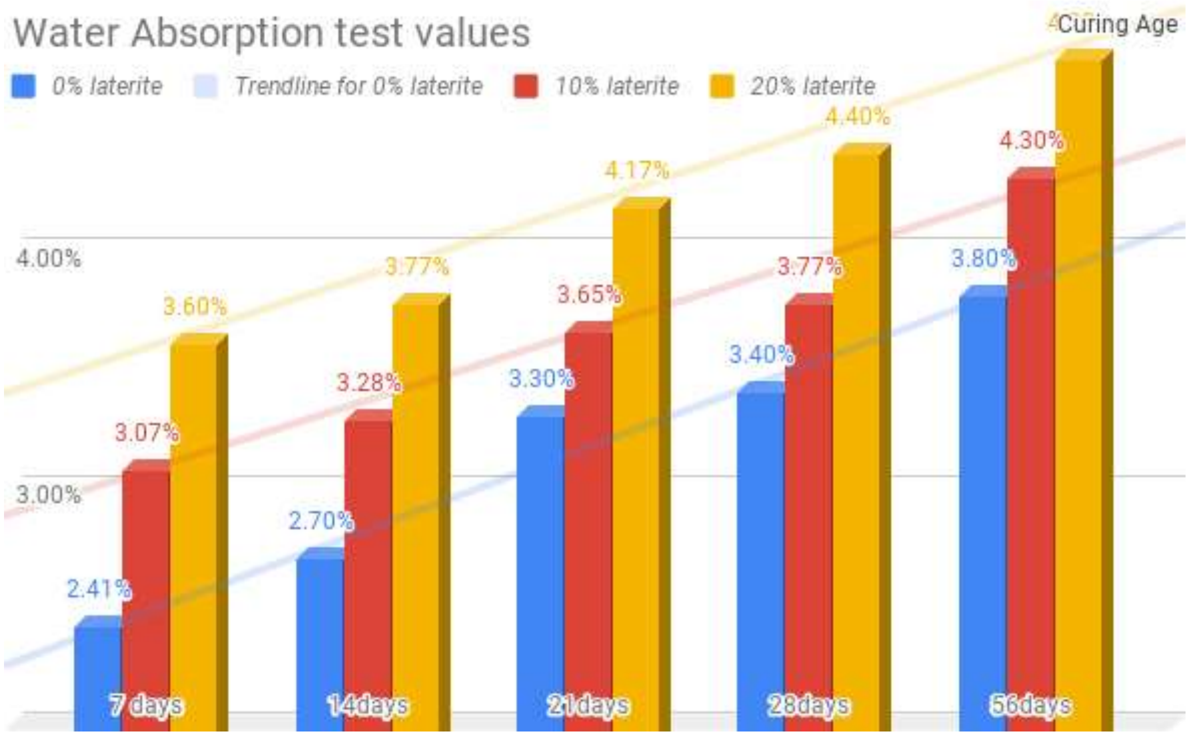

Figure 3 Variations of Water Absorption at different curing ages for EMC

The summary of test results of the water absorption test presented in Table 1 and Figure 3 shows that Earth Moist Concrete (control i.e. 0% laterite) absorbed more water than Earth Moist Concrete with 10% laterite replacement and 20% laterite replacement. It was observed that the water absorption increased as the volume of laterite increased in the Earth Moist Concrete; this may be due to the filler effect of the laterite in the concrete. The cement fine plus the laterite fines may not have filled more concrete pores in the Earth Moist Concrete with 10% laterite replacement and 20% laterite replacement compared to the Earth Moist Concrete (control i.e. 0% laterite), thus making Earth Moist Concrete (control i.e. 0% laterite) more porous.

3.2. Compressive Strength Test

Compressive strength test was carried out on sample 1-3 to determine the compressive strength.

Table 2 Compressive Strength Test Values

% Replacement	Compressive Strength (N/mm2)				
	7 days	14 days	21 days	28 days	56 days
0	18.3	19.2	19.7	20.6	20.9
10	16.5	17.3	18.7	19.1	20.2
20	15.7	16.1	17	18	19.1

The compressive strength of all Earth Moist Concrete specimens increased with age but decreased with increase in the laterite replacement as shown in Table 2 and Figure 4. The required strength of C20 (20 N/mm^2) was attained for Earth Moist Concrete (0% laterite replacement) at 28days while Earth Moist Concrete with 10% and 20% laterite replacement were reasonably lower than the design strength (i.e. 20N/mm^2) in 28days but could likely achieve the design strength at 56days and beyond.

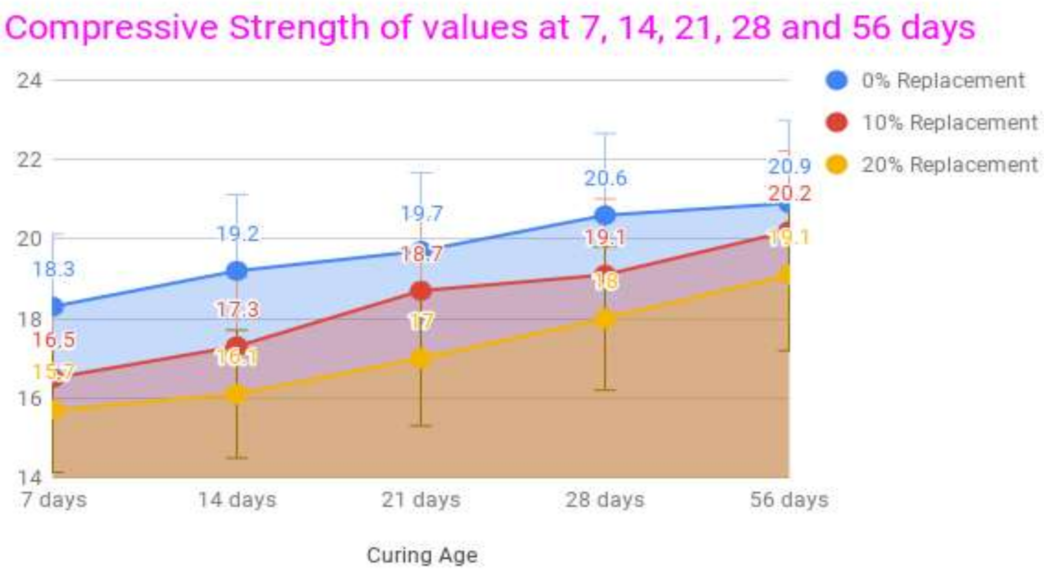

Figure 4 Variation of values of compressive strength at different curing ages for EMC

Therefore, on the basis of compressive strength, Earth Moist Concrete with laterite as partial replacement for fine aggregate (sand) would be suitable for the production of interlocking paving stones, Kerbs, Flags, paving slabs but not for constructing reinforced concrete elements (i.e. columns, slab and beams) since it didn't meet the minimum design criteria for grade C20 for 28days, while Earth Moist Concrete with 0% laterite replacement would be suitable for the production of Concrete paving stones, Kerbs, Flags, paving slabs and constructing reinforced concrete elements. It should also be noted that a good number of structural members such as columns and slabs under mild conditions of exposure in lightly-loaded structures typical of residential buildings frequently do not require very high values of concrete characteristic strength. BS 8110-1: 19.97 [30] specified a minimum strength of 20N/mm^2 for such lightly loaded structural members.

4. CONCLUSION

The conclusions drawn from the result of this study are as follows;

1. The strength of the Earth Moist Concrete increases as the curing age increases and decreases with increasing percentage of laterite.
2. Partially laterized earth moist concrete did not attain the design strength for C20 at 28days but with time it will attain the required strength.

Earth Moist Concrete with laterite as partial replacement with fine aggregates (sand) would be suitable for the production of interlocking paving stones, Kerbs, Flags, paving slabs but not for constructing reinforced concrete elements (i.e. columns, slab and beams) since it didn't meet the minimum design criteria for grade C20 for 28days. While Earth Moist Concrete with 0% laterite replacement would be suitable for the production of interlocking paving stones, Kerbs, Flags, paving slabs and constructing reinforced concrete elements.

The combination of Earth Moist Concrete and partially laterized earth moist concrete can be used for more sensitive structures; in which earth moist concrete could be used in casting members under moderate and harsher conditions of exposure such as foundations and other members in continuous contact with water. Partially laterized earth moist concrete is suitable for production of interlocking paving stones, kerbs and paving slabs used during construction works.

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